OsteoArthritis and Cartilage (2004) 12, 692–697

doi:10.1016/j.joca.2004.05.010

Osteoarthritis and Cartilage

International Cartilage Repair Society

OARSI OSTEOARTHRITIS RESEARCH SOCIETY INTERNATIONAL

The relationship of hip joint space to self reported hip pain A survey of 4.151 subjects of the Copenhagen City Heart Study: the Osteoarthritis Substudy[1]

Steffen Jacobsen M.D.†‡*, Stig Sonne-Holm M.D., Dr Sci.‡§, Kjeld Søballe M.D., Dr Sci.‖, Peter Gebuhr M.D.‡§ and Bjarne Lund M.D., Dr Sci.†

† *Department of Orthopaedic Surgery, Copenhagen University Hospital, Rigshospitalet, Denmark*
‡ *The Copenhagen City Heart Study: The Osteoarthritis Substudy, Denmark*
§ *Department of Orthopaedic Surgery, Copenhagen University Hospital, Hvidovre Hospital, Denmark*
‖ *Department of Orthopaedic Surgery, Aarhus University Hospital, Aarhus Amtssygehus, Denmark*

Summary

Objectives: (1) To evaluate the effect of pelvic orientation on measurements of hip joint space widths (JSW) in cadaver pelvic radiographs, thereby validating the pelvic radiographs of the Copenhagen City Heart Study: The Osteoarthritis Substudy (CCHS III) cohort of 4.152 subjects, and (2) to investigate the relationship between minimal JSW and self reported hip pain of the cohort.

Methods: (1) Cadaver pelves and proximal femora of one male and one female donor were mounted in holding devices permitting independent rotation (total arc of 42°), and inclination/reclination (total arc of 24°). At each 3° increment an anteroposterior radiograph was recorded. Measurements of JSW were performed. (2) Self reported recurrent pain in or around the hip joint during 12 months prior to baseline examinations, and minimum JSW in pelvic radiographs of the cohort were registered. Relationships between minimum JSW and self reported pain were investigated.

Results: (1) Measurements of hip JSW in cadaver radiographs were not influenced significantly by rotation. Measurements of JSW were inconclusively influenced by varying inclination/reclination. (2) Minimum JSW $\leq$ 2.0 mm was significantly associated to self reported pain in or around the hip joint in both sexes.

Conclusion: Measurements of minimum hip JSW did not seem to be significantly influenced by varying spatial orientation of the pelvis during X-ray recordings. An inclusion criteria of minimum JSW $\leq$ 2.0 mm designating definite degenerative pathology in hips will be used by the current authors in future studies.

Key words: Joint space width, Hip, Osteoarthritis, Epidemiology.

Introduction

The lack of a consensus definition of radiologic osteoarthritis (OA) is an ongoing problem in the research of OA. Studies of hip OA have used composite radiologic classifications such as Kellgren–Lawrence's or Croft's scale, or assessed individual radiologic features of degenerative bone reaction as suggested by Altman *et al.*[1,2]. Consequently, prevalences and incidences of radiologic hip OA vary, and meaningful comparisons of results have been difficult. In addition, studies of individual risk factors for incident hip OA have used urograms or colon radiographs as the primary radiologic source material. Usually there is insufficient information regarding rotation or inclination/reclination of the pelvis, the distance between tube and film, or centering of the X-ray beam in these studies[3–7].

The measurement of minimal hip joint space width (JSW) is generally acknowledged as the cardinal individual radiologic feature in assessments of radiologic hip OA and for monitoring progression of degeneration over time[8–11]. The method is fairly reproducible and accurate. Correlations to actual clinical status of patients also seem to be satisfactorily reflected by changes in minimal JSW[8–10]. However, the cutoff value of minimal JSW designating definite hip OA has ranged arbitrarily from 1.5 to 4.0 mm, and studies of the normal distribution of JSW have been absent from the literature until recently; Lanyon *et al.* documented significant age and sex related differences in hip JSW in *asymptomatic* subjects[12].

Auleley *et al.*[13] have demonstrated significant differences in JSW due to alterations in internal rotation of the feet or varying centering of the X-ray beam during recording. However, to our knowledge the relationship of pelvic spatial orientation to JSW measurements has not been investigated.

The aims of this study were: (1) to investigate the relationship of varying pelvic orientation to JSW in radiographs of human cadaver pelves, thereby validating pelvic radiographs from the Copenhagen City Heart study: the

[1]This study has been financially supported by the Research Board of the National University Hospital of Rigshospitalet, the Danish Medical Research Council, the Danish Rheumatism Association, the SAHVA Foundation, Sygekassernes Helsefond, and Biomet-Merck, Denmark.

* Address for correspondence and reprint request to: Steffen Jacobsen, M.D., Baneledet 17, DK-2830 Virum, Denmark. Tel: 45 951 522; E-mail: sjac@dadlnet.dk

Received 5 December 2003; revision accepted 17 May 2004.

Osteoarthritis Substudy (CCHS III) cohort of 4.151 participants, and (2) to investigate the relationship between minimum JSW and self reported hip pain of the cohort.

Materials and methods

CADAVER STUDY

Pelves and proximal femora were obtained from one male donor aged 65 and one female donor aged 68 without known skeletal pathology. All soft tissues were removed except ligaments. The pelves and femora were mounted anatomically in specially constructed holding devices, permitting independent rotation and inclination (Fig. 1). The transverse plane was defined in trial radiographs by horizontal alignment of the teardrop line. Neutral pelvic rotation was defined in trial radiographs by a foramen obturator index (FOI) of 1.0, in which maximum horizontal width of the right obturator foramen was divided by left obturator foramen width[14]. A pelvic forward inclination of 38° was chosen as the starting point, defined by the mean values of female and male pelvic inclinations of the CCHS III material. The pelves were horizontally rotated in a total arc of 42° from the starting point. The pelves were vertically inclined and reclined through a total arc of 24° from the starting point. Consecutive anteroposterior (AP) radiographs were obtained at each 3° increment. Tube to film distance was 120 cm. The X-ray beam was centered two finger breadths above the symphyseal junction and oriented perpendicular to the film. JSW was measured in each radiograph at three locations: (1) at the lateral margin of the subcondral sclerotic line (‘*the sourcil*’), denoting the lateral aspect of the weight-bearing surface, (2) at the apical transection of the weight-bearing surface by a vertical line through the center of the femoral head, and (3) at the medial margin of the weight-bearing surface bordering on the fovea (Fig. 2). Minimal JSW was selected as the smallest of these three measurements. All measurements were performed by one observer (SJ) using a 0.1 mm graduated magnifying glass (Peak, Japan).

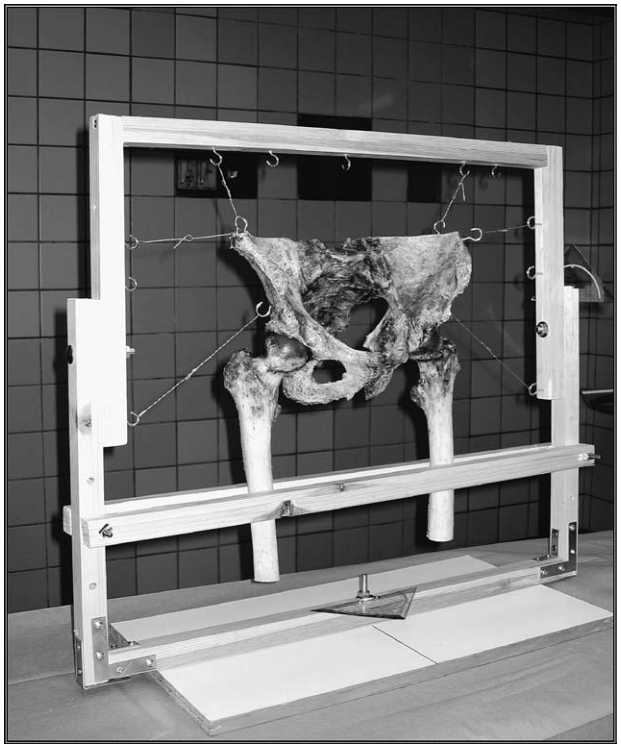

Fig. 1. Pelvis and proximal femora mounted in the holding device.

THE COPENHAGEN CITY HEART STUDY III (CCHS III): THE OSTEOARTHRITIS SUBSTUDY

The CCHS is a longitudinal health survey of an adult, almost entirely Caucasian cohort of the county of Österbro in Copenhagen. The survey has registered health status in four surveys since its beginning of 1976[15].

From 1991 to 1994 (CCHS III) 4.151 AP pelvis and lateral lumbar spine radiographs were recorded from the participants of CCHS III. There were 1.533 male participants with an average age of 62.5 years (range, 23–93 years), and 2.618 female participants with an average age of 65.0 years (range, 22–92 years). Radiographs were recorded standing. Feet pointed straight forward, and lower extremities were positioned in neutral abduction–adduction along the functional axis. In AP pelvis radiographs the X-ray beam was centered two finger breadths over the symphysis pubis in the vertical midline. The X-ray beam in lateral lumbar spine radiographs was centered at the apical midpoint of the iliac crista. Tube to film distance was 120 cm in all cases. Two radiology technicians obtained all radiographs. Pelvic inclination was measured in the lateral lumbar spine radiographs as the angle between the horizontal plane and a line parallel to the cranial articulating surface of the sacrum. Minimum JSW was measured by the same method as in the cadaver study by one observer (SJ). The point of maximum narrowing was appointed a degree on a 180° half-circle, encompassing the weight-bearing zone. This half-circle was further divided into three 60° sectors: one lateral sector, one median (apical) sector, and one medial sector.

All participants in the CCHS III answered a questionnaire of past and present musculoskeletal disorders. A subset of

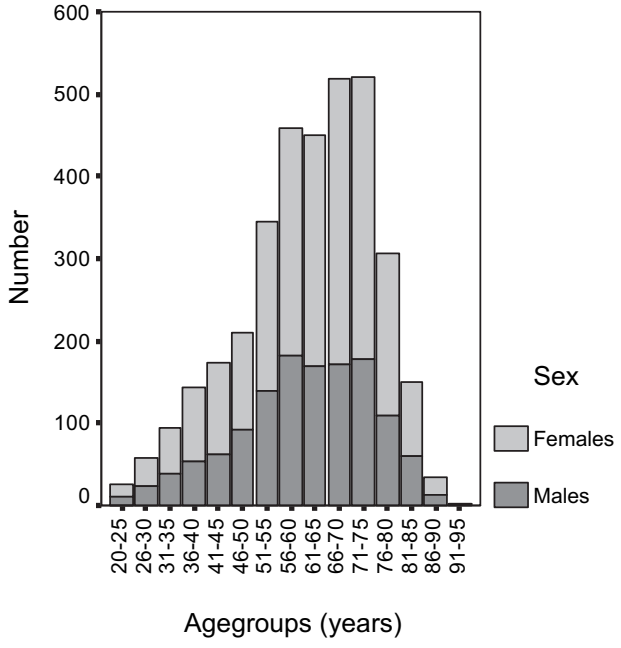

Fig. 2. Distribution of subjects according to age and gender.

questions regarded hip pain. Subjects were asked the following questions: (1) "Have you experienced frequent and recurrent deep pain in the buttocks during the last 12 months?", (2) "Have you experienced frequent and recurrent deep pain of the groins during the last 12 months?", (3) "Have you experienced recurrent hip pain during the last 12 months?", and (4) "Have you experienced deep thigh pain during the last 12 months?". The formulations were chosen to ascertain structural change over time. No statement on laterality or bilaterality was obtained.

REPRODUCIBILITY

Intra-observer repeatability of measurements (SJ) was assessed by blinded re-reading of all cadaver radiographs 4 weeks from the first reading, and by re-reading a subset of 50 of the CCHS III radiographs 4 weeks after first reading. Repeatability was assessed by intra-class coefficients.

STATISTICAL ANALYSIS

Paired samples *t*-tests estimated differences of the location of minimum JSW on a weight-bearing arc of 180° between the two sexes. Paired samples *t*-tests estimated sex related differences in mean minimum JSW. Spearman's correlation coefficient *rho* was used for calculating the linear relationship of varying inclination and rotation of cadaver pelves to measured JSW. Chi-square tests calculated statistical significances of minimum JSW intervals to self reported pain in and around the hip joint. Chi-square tests were applied to sex related differences in self reported pain. Independent samples *t*-tests estimated differences of minimum JSW between subjects with reported pain and subjects without pain. A significance level of $P < 0.05$ was chosen for all calculations. All statistical analysis was performed by the SPSS 11.5 statistical software (SPSS, Chicago, IL).

Results

REPRODUCIBILITY

Repeatability of measurements of minimum JSW in CCHS III radiographs was acceptable: intra-class correlation coefficients of minimum JSW were $r = 0.91$ for right hips and $r = 0.87$ for left hips. Repeatability of measurements of minimum JSW in cadaver pelves was acceptable: intra-class coefficients of minimum JSW was $r = 0.90$ for right hips and $r = 0.90$ for left hips.

CADAVER STUDY

The effects of varying pelvic orientation on the measurements of minimum JSW in cadaver pelves are summarized in Table I. JSW measurements were not affected by varying pelvic rotation in either the male or the female cadaver pelves. Female right hip JSW measurements were significantly affected by varying inclination/reclination. Female left hip medial JSW was also significantly affected by varying inclination/reclination. No similar effect of varying inclination/reclination on JSW measurements was established in the male cadaver.

However, we regard extreme variations of pelvic inclination in standing pelvic radiographs as a possible source of error in JSW measurements. Consequently the current authors have chosen to omit CCHS III sets of radiographs if pelvic inclination exceeded two standard deviations (SD) from the mean.

Table I

Correlation coefficients between varying cadaver pelvic inclination/rotation and measurements of JSW. Pelvic tilt through arc of 24° (12° inclination/12° reclination) from 38° starting position. Pelvic rotation through arc of 42° (21° right/21° left rotation) from neutral

	Pelvic tilt			Pelvic rotation		
	JSW (mm)	*r*	*P*	JSW (mm)	*r*	*P*
Male cadaver pelvis						
Right lateral	1.74	0.06	0.89	3.00	0.09	0.73
Right apical	3.01	0.61	0.14	3.01	−0.13	0.62
Right medial	3.80	−0.39	0.38	3.08	0.15	0.57
Left lateral	2.55	0.60	0.14	2.78	0.06	0.81
Left apical	2.01	−0.20	0.66	2.72	0.36	0.17
Left medial	3.20	0.41	0.35	4.08	−0.16	0.56
Female cadaver pelvis						
Right lateral	4.02	0.74	0.02	3.25	0.33	0.22
Right apical	4.06	0.69	0.04	2.96	−0.00	0.98
Right medial	3.34	0.81	0.00	1.75	0.05	0.85
Left lateral	2.30	−0.38	0.30	2.40	0.21	0.45
Left apical	2.13	−0.14	0.70	2.46	0.30	0.20
Left medial	0.94	0.63	<0.05	0.86	0.15	0.57

JSW = Joint space width. R = Spearman's correlation coefficient rho.

THE COPENHAGEN CITY HEART STUDY (CCHS III)

Pelvic inclination had been assessed in 4.108 lumbar spine radiographs of the original 4.151 participants. Due to obesity, severe lumbar spondylosis or spondylolisthesis accurate assessment of pelvic inclination was not possible in 43 participants. In males, mean pelvic inclination was 38.0° (range, 0°−82°). Applying inclusion limits of 2 SD; participants with pelvic inclinations from 19.3° to 56.7° were selected for further study. Consequently the male cohort decreased at this stage from 1.544 participants to 1.475. In females mean pelvic inclination was 38.0° (range, 0°−89°), and female participants with pelvic inclinations from 18.9° to 57.1° were selected, thereby reducing the original female cohort from 2.564 to 2.460. A total of 8.6% ($n = 173$) sets of CCHS III radiographs were omitted from further study.

This study concentrated on hip pain due to degenerative OA. Since hip pain can be caused by disorders other than OA, participants with registered rheumatoid arthritis, childhood hip disorders, severe lower back disorder, earlier spine surgery procedures, hip fracture, radicular pain, a history of thromboembolic episodes, and slipped discs were also excluded from the study ($n = 727$). We finally included 1.215 men and 1.993 women for further study. The distribution of subjects according to age and gender is presented in Fig. 2.

Right hip minimal JSW was located in the lateral 60° sector of the total 180° weight-bearing arc in 17.0% of cases, in the apical 60° sector in 76.8% of cases, and in the medial 60° sector in 6.2 of the cases. Left minimal JSW was located in the lateral 60° sector of the weight-bearing zone in 19.4% of the cases, in the apical 60° sector in 76.8 of the cases, and in the medial 60° sector in 3.8% of the cases. There was no significant difference in location of minimal JSW between sexes ($P = 0.824$).

Mean minimum JSW was 3.88 mm (range, 0.0−6.5 mm; SD = 0.89) in male right hips, and 3.85 mm (range,

Table II
Prevalences of self reported pain and sex related differences

	Men ($n = 1.215$)		Women ($n = 1.993$)		Differences		
	n	(%)	*n*	(%)	*P*	OR	(95% CI)
Gluteal pain	207	(17.0)	526	(26.4)	0.00	1.7	(1.4–2.1)
Hip pain	270	(22.1)	571	(28.7)	0.00	1.3	(1.1–1.6)
Groin pain	162	(13.3)	272	(13.6)	0.44	1.0	(0.8–1.2)
Thigh pain	239	(19.6)	544	(27.3)	0.00	1.5	(1.2–1.7)
Pain in all regions	30	(2.4)	104	(5.2)	0.00	2.1	(1.4–3.2)
Pain in only one region	460	(37.8)	915	(45.9)	0.00	1.3	(1.1–1.5)

0.0–8.0 mm; SD = 0.91) in male left hips. The corresponding values for women were 3.76 mm (range, 0.0–7.0 mm; SD = 0.82), and 3.73 mm (range, 0.00–8.00 mm; SD = 0.80). Male minimum JSW was significantly larger in men on both sides ($P < 0.0001$).

Prevalences of self reported pain are presented in Table II. Women reported pain significantly more often than men irrespective of age, apart from groin pain ($P = 0.44$).

Pain in *all* regions was only reported in 32 of 1.221 men (2.6%), and in 109 of 1993 women (5.5%). Conversely, the number of cases with pain in only one region was high, 48% for males and 39.4% for females. For further analysis, the current authors have thus chosen to treat the categories of reported hip pain independently.

Minimum JSW measurements in subjects with and without reported pain are presented in Table III. In male left hips mean minimum JSW was significantly narrower in subjects that complained of recurrent hip pain compared to subjects that had no hip pain. There were no statistically significant differences of mean minimum JSW in any other region of the male hip joints. In females no significant differences of mean JSW between subjects with self reported pain and subjects without pain were found.

The relationship of minimum JSW to self reported hip pain is summarized in Table IV. Minimum JSW was initially divided into 0.5 mm intervals. For each subject the hip with narrowest joint space was chosen for analysis. Chi-square statistics was employed in each interval.

In both males and females significant relationships of reported hip pain, groin pain, thigh pain, pain in all regions, and pain in only one region were found if minimum JSW was less than 2.0 mm. For gluteal pain, no statistical relationship was found to minimum JSW.

Discussion

In global radiological classifications of OA such as the Kellgren–Lawrence score, the notion of a certain sequence of degeneration is implicit: narrowing of joint space precedes the development of osteophytes which precedes subcondral sclerosis which precedes the formation of cysts which precedes deformation of the femoral head and acetabulum[16]. Croft's widely used update of the Kellgren–Lawrence classification does not have this premise of a causal chain of degeneration: one is able to choose two to four out of five different radiographic features in characterizing the level of degeneration[17]. This is an advantage; a certain sequence of degenerative bone reaction has not been documented in the literature[11].

Inter- and intra-observer reliability of readings of individual features such as JSW is generally superior to global OA scales[8,9,18]. However, the characterization of JSW is seldom based on any extensive knowledge of the normal distribution of JSW in the population at large, and age and sex differences of JSW are usually not taken into consideration. The terminology of JSW in global classifications is relative at the point of being meaningless. In an atlas of the Kellgren–Lawrence score, reduction of JSW is labelled "possible", "definite", "marked", or "gross"[7]. In the widely used Croft score[3], JSW is either "narrowed" or not[19].

In the prevalence study of hip OA in Malmö, Danielsson defined a minimal normal JSW of 4 mm for subjects <60 years, and 3 mm for subjects >60 years to designate definite OA[4]. The readings were based on colon radiographs. In his studies of Icelandic hip OA, Ingvarsson defined 2.5 mm as the critical minimal JSW using colon radiographs[5].

Croft reported a correlation of clinical hip OA to radiologic evidence of minimum JSW < 2.5 mm (28.3% of painful hips), regardless of the presence or absence of other radiologic features. If minimal JSW < 1.5 mm correlation to clinical OA increased to 56%. Croft concluded that the single reading of JSW was superior to the universal scale in terms of reflecting actual clinical disease[17].

Lanyon *et al.* reported that measurements of JSW were highly reproducible within 0.5 mm in a cohort of 758 males

Table III
JSW in subjects with hip pain, compared to JSW in subjects without pain

Reported pain	Men (1.215)						Women ($n = 1.973$)					
	Right hip			Left hip			Right hip			Left hip		
	n	JSW (mm)	*P*	*n*	JSW (mm)	*P*	*n*	JSW (mm)	*P*	*n*	JSW (mm)	*P*
No hip pain	949	3.90	–	949	3.94	–	1.416	3.74	–	1.413	3.71	–
Hip pain	266	3.80	0.10	266	3.68	0.00	557	3.77	0.38	560	3.74	0.48
No groin pain	1.054	3.89	–	1.055	3.88	–	1.710	3.75	–	1.707	3.72	–
Groin pain	161	3.80	0.22	160	3.74	0.07	263	3.72	0.58	266	3.72	0.88
No gluteal pain	1.011	3.87	–	1.013	3.86	–	1.454	3.72	–	1.454	3.70	–
Gluteal pain	204	3.90	0.71	202	3.87	0.92	519	3.82	0.63	519	3.78	0.55
No thigh pain	978	3.89	–	981	3.88	–	1.443	3.76	–	1.436	3.72	–
Thigh pain	237	3.85	0.54	234	3.77	0.09	530	3.72	0.43	537	3.71	0.73
No pain in all regions	1.184	3.88	–	1.184	3.86	–	1.868	3.74	–	1.867	3.72	–
Pain in all regions	31	3.65	0.15	31	3.75	0.51	105	3.81	0.39	106	3.70	0.80
No pain in any region	738	3.90	–	738	3.92	–	1.032	3.74	–	1.028	3.69	–
Pain in any region	477	3.85	0.40	477	3.77	0.00	941	3.76	0.66	945	3.74	0.18

JSW = mean joint space width. Pain in all regions = reported pain simultaneously in all regions; hip, buttock, thigh and groin. Pain in any region = reported pain in only one region.

Table IV
Relationships between self reported hip pain and minimum hip JSW

JSW ≤ 2.0 mm	Males (n = 1.215)				Females (n = 1.993)			
	n/*N*	*P*	OR	(95% CI)	*n*/*N*	*P*	OR	(95% CI)
Gluteal pain	12/73	0.56	0.9	(0.5−1.8)	29/113	0.51	0.9	(0.6−1.5)
Hip pain	35/73	0.00	3.5	(2.1−5.7)	45/113	0.005	1.7	(1.1−2.5)
Groin pain	18/73	0.003	2.3	(1.3−4.1)	26/113	0.004	2.0	(1.3−3.2)
Thigh pain	23/73	0.008	1.9	(1.1−3.3)	41/113	0.01	1.5	(1.0−2.3)
All regions	4/73	0.09	2.5	(0.8−7.4)	8/113	0.20	1.4	(0.6−3.1)
Only one region	62/113	0.01	1.5	(1.0−2.3)	44/73	0.00	2.7	(1.6−4.4)

JSW = minimum joint space width. n = Number of subjects with reported symptom in given JSW interval. N = Total number of subjects in given JSW interval. P = Significance at the 0.05 level. OR = Odds ratio; CI = Confidence interval.

(mean age 65.1 years), and 1.048 females (mean age 65.2 years). Mean minimum JSW at the site of maximum narrowing was 4.19 mm in men and 3.85 mm in women. Minimum JSW decreased with increasing age in women, but was unaltered in men. The authors suggested using sex-specific cutoff values for JSW in epidemiological studies, reducing significant minimum JSW to 2.2 mm in women, and keeping the limit of 2.5 mm for men. Applying these criteria, radiologic OA prevalence was reduced for women from 10.6% to 5.6% among subjects 45−84 years of age. Prevalence of hip pain was 37.7% in women and 20.5% in men. Lanyon *et al.* found positive correlations between height and minimal JSW in both sexes ($P < 0.001$ for women, and $P < 0.001$ for men)[12].

Needless to say, these findings have important implications for future case definitions of radiologic OA.

Altman *et al.* found that a single AP radiograph assessed for joint space narrowing and the formation of cysts yielded the greatest sensitivity regarding progression of hip OA over a period of 12−60 months[1]. Dougados *et al.* and Maillefert *et al.* arrived at the same conclusion, tracing progression of hip OA. A change in minimal JSW, of 0.6 mm and 0.4 mm in males and females, respectively, correlated well with changes in patients' clinical status[5,10].

In an SOF study, Lane *et al.* found superior inter-rater repeatability of minimum JSW measurements compared to other individual features of radiological OA, not only in the hip but also in the hand and spine of women aged 65 and older[18].

To improve inclusions and correlations in future epidemiological and clinical studies of hip OA, the current authors have investigated the relationship of minimum hip JSW to self reported recurrent pain in and around the hip joint over a period of 12 months prior to baseline examinations and interviews. Overall, the authors found no statistical significant correlations of mean minimum JSW in subjects with reported pain to subjects with no pain. However, the authors found a statistically significant overrepresentation of subjects with reported groin pain, thigh pain, hip pain, pain in all regions and pain in only one region, if minimum JSW ≤ 2.0 mm was applied, which equalizes mean minimum JSW minus 2 SD in both sexes.

To validate our own radiographic source material of 4.151 standardized, weight-bearing pelvic and lumbar spine radiographs for future studies, the authors conducted a cadaver study of one male and one female cadaver pelvis, mounted in a specially designed holding device that permitted independent rotation and inclination/reclination of the pelvis during X-ray recordings. We found that measurements of JSW were particularly robust in regard to varying rotation through a total arc of 42°. With varying inclination/reclination through a total arc of 24°, some measurements of JSW were significantly influenced (female cadaver, right hip/male cadaver, left hip, apical JSW). The relationship was not convincing enough to merit recommendations regarding the use of urograms or colon radiographs for epidemiological purposes. In addition, one cannot rule out that measurements of JSW in the CCHS III radiographs differ from the cadaver JSW measurements due to weight-bearing. Auleley *et al.* has demonstrated a slight but significant difference in repeated JSW measurements in weight-bearing and supine hip radiographs, JSW surprisingly being increased in weight-bearing radiographs[21].

However, the current authors decided to include only sets of radiographs in which pelvic inclination was inside 2 SD of the mean, thereby omitting 173 (8.6%) of the total sets of radiographs.

We find that caution should be exercised in the inclusion of subjects in epidemiological surveys of hip OA based on measurements of minimum JSW alone, without knowledge of the relativity of the parameter in the population at large. In future epidemiologic studies of hip OA, we will use an inclusion criterion of minimum JSW ≤ 2.0 mm to define hip OA, which corresponds to the results of Lanyon *et al.*[12].

Acknowledgements

The current authors wish to thank Professor Hans Rovsing, M.D., Dr sci. (ret.), and Henrik Monrad, M.D. at the department of radiology, the Copenhagen University Hospital, Hvidovre, for assessing pelvic inclination in all sets of radiographs of the Copenhagen City Heart Study—the Osteoarthritis Substudy 1991−1994. We thank Jette Løje, RN, the scientific assistant of the study for invaluable assistance.

References

1. Altman RD, Fries JF, Bloch DA, Carstens J, Cooke TD, Genant H, *et al.* Radiographic assessment of progression in osteoarthritis. Arthritis Rheum 1987;30: 1214−25.
2. Altman RD, Hochberg M, Murphy Jr WA, Wolfe F, Lequesne M. Atlas of individual radiographic features in osteoarthritis. Osteoarthritis Cartilage 1995;3(Suppl A):3−70.
3. Croft P, Cooper C, Coggon D. Case definition of hip osteoarthritis in epidemiologic studies. J Rheumatol 1994;21:591−2.
4. Danielsson L, Lindberg H, Nilsson B. Prevalence of coxarthrosis. Clin Orthop 1984;110−5.

5. Ingvarsson T. Prevalence and inheritance of hip osteoarthritis in Iceland. Acta Orthop Scand 2000; 298(Suppl):1–46.
6. Lau EM, Lin F, Lam D, Silman A, Croft P. Hip osteoarthritis and dysplasia in Chinese men. Ann Rheum Dis 1995;54:965–9.
7. Smith RW, Egger P, Coggon D, Cawley MI, Cooper C. Osteoarthritis of the hip joint and acetabular dysplasia in women. Ann Rheum Dis 1995;54:179–81.
8. Dougados M, Gueguen A, Nguyen M, Berdah L, Lequesne M, Mazieres B, *et al*. Radiological progression of hip osteoarthritis: definition, risk factors and correlations with clinical status. Ann Rheum Dis 1996;55:356–62.
9. Dougados M, Gueguen A, Nguyen M, Berdah L, Lequesne M, Mazieres B, *et al*. Radiographic features predictive of radiographic progression of hip osteoarthritis. Rev Rheum Engl Ed 1997;64:795–803.
10. Maillefert JF, Gueguen A, Nguyen M, Berdah L, Lequesne M, Mazieres B, *et al*. Relevant change in radiological progression in patients with hip osteoarthritis. I. Determination using predictive validity for total hip arthroplasty. Rheumatology 2002;41:142–7.
11. Spector TD, Cooper C. Radiographic assessment of osteoarthritis in population studies: whither Kellgren and Lawrence? Osteoarthritis Cartilage 1993;1:203–6.
12. Lanyon P, Muir K, Doherty S, Doherty M. Age and sex differences in hip joint space among asymptomatic subjects without structural change: implications for epidemiologic studies. Arthritis Rheum 2003;48: 1041–6.
13. Auleley GR, Duche A, Drape JL, Dougados M, Ravaud P. Measurement of joint space width in hip osteoarthritis: influence of joint positioning and radiographic procedure. Rheumatology 2001;40:414–9.
14. Tonnis D. Normal values of the hip joint for the evaluation of X-rays in children and adults. Clin Orthop 1976;39–47.
15. Schnohr P, Jensen G, Lange P, Scharling H, Appleyard M. The Copenhagen City Heart Study—Österbroundersøgelsen—tables with data from the third examination 1991–1994. Eur Heart Journal 2001;3(Suppl H):1–83.
16. Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthritis. Ann Rheum Dis 1957;16:494–502.
17. Croft P, Cooper C, Wickham C, Coggon D. Defining osteoarthritis of the hip for epidemiologic studies. Am J Epidemiol 1990;132:514–22.
18. Lane NE, Nevitt MC, Genant HK, Hochberg MC. Reliability of new indices of radiographic osteoarthritis of the hand and hip and lumbar disc degeneration. J Rheumatol 1993;20:1911–8.
19. The Department of Rheumatology, University of Manchester and Manchester Royal Infirmary. The Epidemiology of Chronic Rheumatism Volume II: Atlas of Standard Radiographs of Arthritis. Oxford: Blackwell Scientific Publications 1963; pp. 1–44.
21. Auleley GR, Rousselin B, Ayral X, Edouard-Noel R, Dougados M, Ravaud P. Osteoarthritis of the hip: agreement between joint space width measurements on standing and supine conventional radiographs. Ann Rheum Dis 1998;57:519–23.